



## **Method for manufacturing of light emitting device with composed chemical semiconductor**

**[0001]** This Nonprovisional application claims priority under 35 U.S.C. § 119(a) on Patent Application No. 10-2003-0014381 filed in Korea on March 7, 2003, the entire contents of which are hereby incorporated by reference.

### **BACKGROUND OF THE INVENTION**

#### **Field of the Invention**

**[0002]** The present invention relates to a method for manufacturing a light-emitting device with a compound semiconductor and more particularly, a method for manufacturing a light-emitting device with a Group III - V compound semiconductor for increasing a light-emitting efficiency or long durability of elements, by conducting of a heat-treatment at a lower temperature than done at in the conventional art, i.e. activating a p-semiconductor layer under the condition of high oxygen density, which idea is derived from the well known fact that on the higher oxygen density, the better semiconductor layer doped with p-type such like p-GaN can be activated.

#### **Description of the Background Art**

**[0003]** Generally, ~~The~~the Group III - V compound semiconductor as a kind of a direct transition type, has a high light-emitting efficiency so the semiconductor

is used ~~very~~ widely for light-emitting elements such ~~like~~as diode elements (laser diode elements), photodetectors (solar battery, optical sensors), electronic devices (transistor, power device) and so on.

**[0004]** A method for manufacturing ~~of said~~the Group III - V compound semiconductor has three methods which are MBE (Molecular Beam Epitaxy), MOVPE (Metal Organic Vapor Phase Epitaxy), and HVPE (Hydride Vapor Phase Epitaxy).

**[0005]** Particularly, the MOVPE method has been used widely as a method for manufacturing a Group III - V compound semiconductor because it can achieve ~~an~~a uniformed Group III - V compound semiconductor with ~~and~~a high quality. Fig. 1 shows a light-emitting element manufactured following the conventional art of MOVPE.

**[0006]** As shown in Fig. 1, the conventional light-emitting elements of the Group III - V compound semiconductor has a Gallium-Niride layer(n-GaN)(11) doped with n-type on the top of a sapphire substrate (10) and an activated layer (12) is formed thereon. The p-GaN doped with p-type (13) is formed on the activated layer (12) and a part of the n-GaN layer (11) ~~become to be~~is exposed and the n-pad electrode (15) is formed thereon. Further, a transparent electrode (14) and the p-pad electrode (16) for extending an electric current is formed in sequence on the top of ~~said~~the p-GaN layer (13).

**[0007]** The ~~said~~ Group III - V compound semiconductor formed as above, especially the p-GaN layer 13 is ~~conducting~~formed with a heat-treatment under

the condition of Nitrogen and Oxygen at in the conventional art because it ~~have~~has to be formed with a high hole concentration.

**[0008]** For example, if the p-GaN doped with p-type ~~with~~using Magnesium is formed by the MOCVD method, a magnesium acceptor cannot be activated but rather is combined to a hydrogen so that a neutrality complex, Mg-H is formed ~~by~~. In order to prevent ~~the said matter~~this, a high heat treatment ~~make~~is used to break Mg-H's bonding ~~cut and then it makes Hydrogen which was combined to magnesium will be out~~.

**[0009]** However, the high-temperature treatment needs ~~lots a~~lot of thermal energy. Also, ~~it occurred several problems~~ occur such as a deterioration and a deformation of the ~~said~~ Group III - V compound semiconductor so the durability and light-emitting efficiency of the light-emitting elements is decreased.

### SUMMARY OF THE INVENTION

**[0010]** The object of the present invention is to provide a method for manufacturing a light-emitting device with a compound semiconductor in order to solve the above problems.

**[0011]** The present invention is a method for manufacturing a light-emitting device with a compound semiconductor ~~comprising; a first step of~~including forming an n-semiconductor layer, an activated layer, and a p-semiconductor layer in order on ~~the top of a double substrate, a second step of~~ making a part of the n-semiconductor with ~~that a~~ mesa-cut in a vertical direction from ~~a~~the p-

- 4 -

semiconductor layer to a part of the n-semiconductor, ~~a third step of forming a~~ transparent electrode for extending an electric current on the top of the p-semiconductor layer and activating the p-semiconductor layer under the condition of an oxygen plasma, and ~~a fourth step of forming each of the an~~ n- pad electrode and the p-pad electrode on the top of the transparent electrode for extending an electric current.

[0012] ~~Said~~The double substrate is preferably a sapphire substrate. Also, it is ~~prefer~~preferable that the p-semiconductor and the n-semiconductor layer is a Group III-V compound semiconductor, especially a GaN layer.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The invention will be described in detail with reference to the following drawings in which like numerals refer to like elements.

[0014] Fig. 1 shows a light-emitting element manufactured following the conventional art of MOVPE.

[0015] Fig. 2a to Fig. 2e show the sequence of a method for manufacturing a light-emitting device according to ~~of~~-preferred embodiments of the present invention.

#### DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0016] Preferred embodiments of the present invention will be described in a more detailed manner with reference to the drawings.

- 5 -

**[0017]** The present invention is a method for manufacturing light-emitting device with compound semiconductor comprising; ~~a first step of forming an~~ n-semiconductor layer, an activated layer, and a p-semiconductor layer in order on the top of a double substrate, ~~a second step of making a part of the n-semiconductor with that a mesa-cut in the~~ vertical direction from a p-semiconductor layer to a part of the n-semiconductor, ~~a third step of forming a transparent electrode for extending an electric current on the top of the p-semiconductor layer and activating the p-semiconductor layer under the condition of an oxygen plasma, and a fourth step of forming each of the~~ an n- pad electrode and the p-pad electrode on the top of the transparent electrode for extending an electric current.

**[0018]** First of all, a method for manufacturing a light-emitting device with a compound semiconductor according to the present invention, is to ~~be grown~~ Epi as forming an n-type compound semiconductor layer\_(n-semiconductor layer), an activated layer, and a p-type compound semiconductor layer\_(p-semiconductor layer) in order on the top of the double substrate ~~by using of a method of MOVPE~~ growth.

**[0019]** And then, a part of the n-semiconductor layer is ~~made exposed by a~~ mesa-cut in a vertical direction of the semiconductor which is from the p-semiconductor to the part of the n-semiconductor.

**[0020]** After that, a transparent electrode for extending an electric current ~~which is made by a metal material is formed on the top of said~~ the p-

- 6 -

semiconductor layer and, ~~conduct of the~~ heat-treatment is conducted for the p-semiconductor layer's activation ~~at the same time when a~~causing the p-semiconductor layer to omic-connect to the transparent electrode.

**[0021]** At that time, ~~based on the fact that~~because the p-semiconductor layer can be better activated ~~more~~ under the condition of ~~the~~a higher O<sub>2</sub> density, the p-semiconductor layer is activated under the condition of Oxygen plasma Ion ~~not like the conventional art instead of~~rather than using an Oxygen molecule or Nitrogen molecule like in the conventional art.

**[0022]** Accordingly, if the p-semiconductor is activated under the condition of an Oxygen or Nitrogen Molecule, H<sub>2</sub> can be out under the condition of molecule as to be separated from the used material when the p-semiconductor layer is grown.

**[0023]** And, ~~it was necessary lots of energy because it have~~in the conventional art, a lot of energy was necessary to conduct ~~of the~~ heat-treatment at 600 °C ~~instead of~~ H<sub>2</sub>O and H<sub>2</sub> of being out easily after being changed O<sub>2</sub> to Oxygen Ion.

**[0024]** So, if maintaining the condition of Oxygen at a low temperature, H<sub>2</sub>O can be out easily and unnecessary energy ~~cannot be~~is not wasted.

**[0025]** ~~If~~In the p-semiconductor layer ~~be~~ activated under the condition of O<sub>2</sub> plasma according to the present invention, the p-semiconductor layer can be better activated ~~better comparing with~~compared to the conventional art which

~~makes it activated~~activates the layer at a high temperature, and ~~it can be saved~~  
the unnecessary thermal energy waste can be saved.

**[0026]** After the p-semiconductor layer is activated through the heat-treatment, a n-pad electrode is formed on ~~the top of the~~ n-semiconductor layer for a wire bonding and a p-pad electrode is formed on ~~the top of the~~ transparent electrode.

**[0027]** Accordingly, ~~as to be activated~~ because the p-semiconductor layer is activated under the condition of the oxygen plasma at low temperature ~~comparing with the conventional art~~, a durability or an efficiency of the light-emitting element can be increased compared to the conventional art.

**[0028]** Fig. 2a to Fig. 2e show the sequence of Preferred embodiments.

**[0029]** At the preferred embodiment, a semiconductor layer is described as a Group III-V compound semiconductor layer, especially a n-semiconductor described "n-GaN", a p-semiconductor described "p-GaN", and a double substrate described sapphire substrate.

**[0030]** First of all, Fig. 2a shows the growth of an n-GaN 21 layer, an activated layer 22, and a p-GaN layer 23 on ~~the top of a~~ sapphire substrate 20 ~~as followed of the method of~~ using the MOVPE growth method.

**[0031]** And then, a part of the n-semiconductor layer 2321 is ~~made~~ exposed by a mesa-cut in a vertical direction ~~of~~ from the p-semiconductor layer 23 to the part of the n-semiconductor layer 21 as described in Fig. 2b, and a transparent

- 8 -

electrode 24 for extending an electric current, which is made by a metal material, is formed on the top of ~~said~~the p-semiconductor layer 23 as described Fig. 2c.

[0032] After that, ~~it conducted of the~~ heat-treatment at the same time when the p-semiconductor layer 23 ~~emc-connect~~omc-connects to the transparent electrode 24 for the p-semiconductor layer's activation.

[0033] At that time, ~~it occurs~~ high resistance occurs because a p-type douse's acceptor such ~~like~~as a magnesium acceptor is combined with Hydrogen. So in order to cut the above bonding in the present invention, ~~it conducts of the~~ heat-treatment is performed under the condition of oxygen.

[0034] ~~In the result~~Thus, it is possible to conduct ~~of the~~a heat-treatment process at a low~~lower~~ temperature ~~comparing with~~compared to the conventional thermal temperature of 600 °C and Hydrogen broken from acceptor can be out as the form of H2O bonding with Oxygen.

[0035] When the ~~above said~~above procedure is finished, an n-pad electrode 25 is formed on the top of the ~~said~~exposed n-GaN layer 21 as described Fig. 2d and ~~p-pad~~ p-pad electrode 26 is formed on ~~the~~ top of the transparent electrode 24 as described Fig. 2e.

[0036] As described hereinabove, according to the present invention, it is possible to reduce unnecessary thermal energy waste because ~~it~~the p-type layer can be activated at a low temperature ~~as p-semiconductor can be activated~~ under the condition of Oxygen. And it has an effect to increase of a durability and an



- 9 -

efficiency of the light-emitting element because the p-semiconductor layer can be better activated ~~better~~.

**[0037]** The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.



# Background Art

Fig. 1

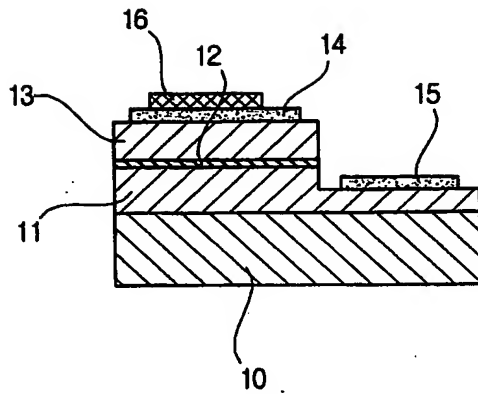


Fig. 2a

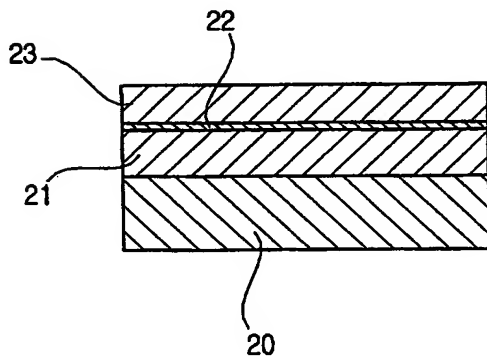
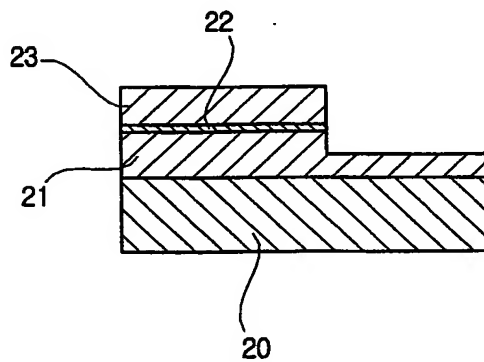


Fig. 2b



# Background Art

Fig. 2c

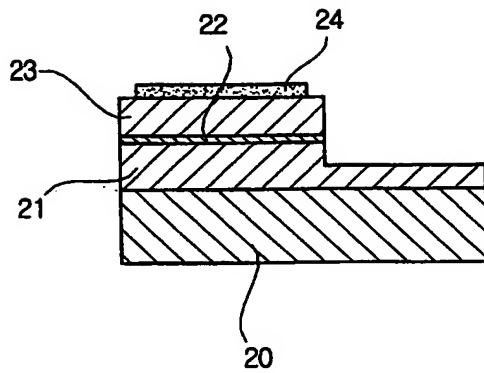


Fig. 2d

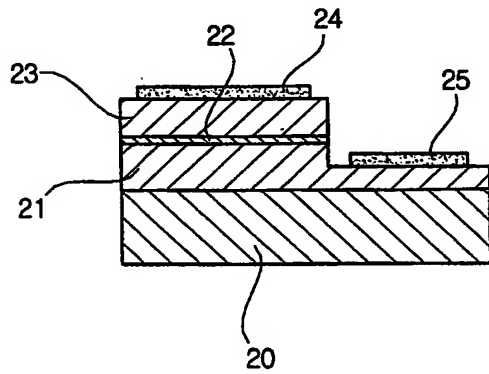


Fig. 2e

